LETTERS TO THE EDITOR

REACTION RATES OF $C^{12}(\alpha, \gamma)^{16}O$ REACTION AFFECTING SCREENING EFFECT

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$C^{12}(\alpha, \gamma)^{16}O$ REACTION rates have been calculated considering screening effect after Mitler[5], Itoh *et al.*[4] and Van Horn and Salpeter[6]. The carbon-carbon interaction rates have been found to bring modification to the duration of destruction of carbon to form iron group of elements in carbon detonation supernova.

Introduction

Once carbon is formed by triple alpha reation, it is destroyed by (α, γ) reaction to yield ^{16}O find so on. Burbidge *et al.*[1] considered these reactions in giant stage of stellar evolution and calculated the reaction rates without considering the screening effect. The work of Duorah[3] can also be improved.

After exhaustion of helium, further gravitational contraction leads to higher temperature. At $T_9 = 0 \cdot 8$, C^{12} may react with C^{12} and at about $T_9 = 1$, ^{16}O may react with ^{16}O in carbon-oxygen degenerate core. The $C^{12}(\alpha, \gamma)^{16}O$ is the reaction to synthesise Ne^{20}, Mg^{24}, etc., while carbon-carbon interaction leads ultimately to the formation of iron group of elements.

The non resonant $C^{12}(\alpha, \gamma)^{16}O$ reaction

This reaction takes place at a temperature of the order 10^8 K and density $10^5 g\ cm^{-3}$. We use here the dimensionless parameter, Γ introduced by Van Horn and Salpeter[6]

$$\Gamma = \frac{z^2 e^2}{a KT} \quad (1)$$

where

$$a = \text{mean ionic distance} = \left(\frac{3}{4\pi n_e}\right)^{1/3}$$

For helium plasma,

$$n_e = 2n_\alpha = 2\left[\frac{\rho N_A X_\alpha}{A_\alpha}\right] cm^{-3}.$$

Taking $\rho X_\alpha = 10^5$ gm/cc, we get,

$$n_\alpha = 1 \cdot 507 \times 10^{28}\ cm^{-3} \quad \text{and}$$

$$a = 10^{-28}/12 \cdot 56^{cm}.$$

Putting n_e and 'a' from the above and $K = 1 \cdot 38 \times 10^{-16}$ erg/K in the expression (1), we get $\Gamma \ll 1$. Hence it is in weak screening regime. We take the well known enhancement factor in weak screening regime to be $\text{Exp}\{3^{1/2}\Gamma^{3/2}\}$ from Itoh *et al.*[4],

The unscreened non resonant reaction rate per particle of type 2 with type 1 is taken from Burbidge *et al.*[1]

$$\rho_{nr} = 4 \cdot 34 \times 10^5 \frac{\rho X_1}{A_1} (Az_1 z_2)^{-1} \tau^2 e^{-\tau} \sec^{-1} \quad (2)$$

The screened reaction rate thus becomes equal to

$$\rho_{nr} = 4 \cdot 34 \times 10^5 \frac{\rho X_1}{A_1} (A z_1 z_2)^{-1} \tau^2 e^{(-\tau + 3^{1/2}\Gamma^{3/2})} \times \sec^{-1} \quad (3)$$

The cross-section factor, S is given by

$$S = \sigma E \exp(31 \cdot 28\, z_0 z_1 A^{1/2} E^{-1/2})\ \text{keV barns.} \quad (4)$$

In this expression σ is the reaction cross-section in barns and E is the particle energy in centre of mass system in KeV. σ's can be found by usual method

$$E = 26 \cdot 28\, (z_0^2 z_1^2 A T_S^2)^{1/3}\ \text{KeV}. \quad (5)$$

τ in the equation (3) is given by

$$\tau = 19 \cdot 72\, (z_0^2 z_1^2 A)^{1/3} T_S^{-1/3}. \quad (6)$$

After, finding the reactions rates by the above equations at temperatures from 10^8 K to 2×10^8 K, the mean life in years (inverse of the rate of destruction) has been found at density, $10^5 g\, cm^{-1}$.

From Table I, we observe that the decrease of mean life in years due to the screening effect is meagre as the screening effect does not augment the reactions much. We add in passing that when Γ is much less than 1, the screening effect of electron cloud have but little effect. If we consider situations in carbon detonation supernova, the density and temperature would be quite large and strong screening will be

TABLE I

Logerithm of mean life (+ in years) in helium burning reactions at $\rho X\alpha = 10^5$ gm/cc

T_8	Γ	$C^{12}(\alpha, \gamma)^{16}O$ rate without screening	$C^{12}(\alpha, \gamma)^{16}O$ rate with screening	Pycno-nuclear rate of Camaron[2] for compariso0
1	·292	7·57	7·45	6·32
1·2	·243	5·94	5·85	4·32
1·6	·182	4·09	4·03	2·30
2	·146	1·91	1·87	..